Rock Chips
Fall 2005

Turtle Mountain Monitoring Project

Panoramic photo taken from South Peak showing the head of the 1903 slide, the town of Frank, the Frank Slide and the town of Bellevue.

Located in southwestern Alberta, Turtle Mountain is the site of one of Canada's most notorious natural disasters, the Frank Slide. The 1903 rock slide buried the Town of Frank under 30 million cubic metres of debris, killing 70 people.

A series of large cracks remains around the south peak of the mountain, prompting speculation that the cracks may widen over time and lead to another rock slide. Experts believe a failure of the south peak could generate a slide with a volume of approximately 5 million cubic metres.

On April 29, 2003, the centennial of the 1903 Frank Slide, the Government of Alberta committed $1.1 million to install and commission a real-time warning system for the South Peak of Turtle Mountain. The project was administered by Emergency Management Alberta (EMA), with technical assistance from the AGS, and was undertaken by a team of contractors and university researchers.

Although involved in a technical capacity in previous activities, as of April 1, 2005, EUB/AGS assumed full responsibility for the monitoring and research activities at Turtle Mountain, including providing guidance to EMA on the potential for a second large rock slide from Turtle Mountain. As a result, AGS has established a long-term program and recruited Corey Froese and Francisco Moreno to carry out these responsibilities.

View from the north across the head of the 1903 slide and South Peak showing the large mass of rock that is moving to the east (left in the photo).

The Turtle Mountain Monitoring Project's (TMMP) objective is to implement a predictive monitoring/early warning system to help mitigate the risk associated with a future rock avalanche from South Peak. Such a system is envisioned as a combination of seismic, displacement, pore pressure, temperature and other monitoring

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instruments operating in near real time. The system will incorporate data-management equipment and facilities, operational and quality assurance procedures, as well as associated emergency plans, planning guidelines and emergency response protocol. Site-specific warning criteria will be developed based on the background and baseline monitoring data from Turtle Mountain.

Implementation of the monitoring system took place in three phases:

- The first phase had an educational monitoring system replace the existing seismic stations and weather station on Turtle Mountain, and established a control centre at the Frank Slide Interpretive Centre. The data obtained from these sensors are being used to determine the influences of climatic and seismic activity on the stability of the mountain.
- The second phase installed a monitoring system with electronic distance measurement (EDM) and differential GPS-based instruments, and a series of crack gauge monitors to assess aperture changes in the major fissures around South Peak.
- Phase three established a predictive monitoring system, incorporating the instruments from the previous two phases, and complementing them with borehole-based instruments to measure displacement, pore pressure, temperature and microseismicity. Outflow monitoring at springs is also being conducted. Several supporting investigative studies and repeated manual measurements and surveys are also planned.

Ben Firth of Vertical Systems International instailing reflective prisms on the eastern face of South Peak.

The project involved drilled-hole and surface installations of various monitoring devices. Drilling equipment was transported by helicopter onto Turtle Mountain to a height of 2200 m. One hole was drilled to

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Components of an air rotary drilling rig being lifted into place on South Peak by a Bell 212 helicopter.

a depth of 62 m into the mountain side, and into this hole sophisticated monitoring equipment was installed to detect movements and changes in conditions on the crest of the mountain. The equipment included extensometers, geophones, time-domain refractometry (TDR) cables, vibrating wire piezometers and thermistors. In addition, an optical televiewer was run down the hole to detect the locations of cracks and cavities in the rock mass.

Drilling of a 62-metre-deep air rotary testhole at South Peak, 1000 metres above the valley floor. The town of Blairmore is in the distance.

Following the installation of the downhole instrumentation, an array of surface instruments were installed, including tiltmeters, crack meters, surface wire extensometers, differential GPS and prisms to be used by an EDM system set-up at the Frank Slide Interpretive Centre. Additionally, a microseismic monitoring system was commissioned to detect minute shifts in the peak of the mountain. This system was complemented with borehole temperature and pore pressure sensors, an outflow weir at the old mine opening and a weather station.

Maintenance of a surface wire extensometer being undertaken by Andrew Bidwell (AMEC Earth and Environmental) and Corey Froese (AGS).

The monitoring data are relayed to the Frank Slide Interpretive Centre, three kilometres away. Using these data, along with information from the installed climatic and surface seismic stations, AGS staff and consultants have worked with Emergency Management Alberta to develop monitoring criteria and an emergency response plan for Frank and other area stakeholders, including Canadian Pacific Railway, Municipality of Crowsnest Pass and Alberta Transportation.

Corey Froese (AGS) with the 1903 slide mass in the background.

Another tool used to better understand surface movement on the mountain was interferometric synthetic aperture radar (InSAR). With this technique, satellite images are used to identify sub-centimetre changes at thousands of discrete points on the mountain and within the debris field.

AGS geologists Willem Langenberg (left) and Dinu Pana (right) mapping the structure and fracture patterns on Turtle Mountain.

Oblique view of the Frank Slide, looking to the northeast, taken from a helicopter.

Long-Term Monitoring

The following are roles and responsibilities of the EUB/AGS for the long-term monitoring of Turtle Mountain:

1. **Recognition of Significant Movement and Invoking the Emergency Response Plan**

   The prime responsibility of AGS is to recognize signs of imminent and significant movement at Turtle Mountain and to invoke the Emergency Response Plan with EMA.

2. **Monitoring System Maintenance and Upgrading**

   In support of the prime responsibility, it is the role of AGS to maintain and upgrade the monitoring system at Turtle Mountain. This includes regular visual checks of equipment and implementation of repairs. AGS will also evaluate opportunities for future upgrades to increase network reliability as technology evolves.

Installation of a crackmeter.

3. **Data Review and Reporting**

   AGS will conduct weekly expert review of data and prepare quarterly summary reports. An annual overview report of the system status and findings on Turtle Mountain motion and deformations will also be prepared.

4. **Emergency Response Planning with EMA**

   EMA is responsible for developing and implementing the emergency response plan (ERP) for Turtle Mountain, with AGS as the key technical advisor. As well, AGS will have a role in response drills to test and improve the ERP in conjunction with EMA.

5. Provision of Subject Matter Experts to EMA

In the event of a significant movement at Turtle Mountain, AGS staff will set up a base at Crowsnest Pass to provide technical expertise for the emergency response team operating under the lead of EMA.

6. Research and Development

The Turtle Mountain Monitoring System provides a world-class field laboratory for research on landslides and monitoring-instrumentation development. It will be an ongoing responsibility for AGS to ensure that Canadian and international researchers get open and safe access to the mountain and monitoring data to facilitate technology transfer and technology development.

To see more information on the Turtle Mountain Monitoring project see the web site at

http://www.ags.gov.ab.ca/activities/Turtle_Mountain/mainpage.htm ❖

View across South Peak showing some of the surface instrumentation installations. The town of Blairmore is in the distance.

Story Contact Information

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Study Done on the Horseshoe Canyon-Bearpaw Transition and Correlation of Associated Coal Zones Across the Alberta Plains - Geo-Note 2005-08

The Horseshoe Canyon Formation contains about 40% of the total coalbed methane gas resources of the Upper Cretaceous-Tertiary succession, of which about 58% are hosted by the Drumheller and the Basal coal zones. This study correlates the Horseshoe Canyon–Bearpaw transition and associated coal zones across central and southern Alberta Plains. As well, it examines outcrops and associated subsurface strata of the Horseshoe Canyon Formation in the Edmonton area.

Three Bearpaw marine tongues are interfingered with the Lower and Middle Horseshoe Canyon Formation. The Lower and Middle Bearpaw marine tongues consist of two distinctive marine regressive (coarsening-up) sequences, whereas the Upper Bearpaw marine tongue consists of only one. At least five major flooding surfaces are present in the Horseshoe Canyon–Bearpaw transitional zone, each marks a marine transgression followed by a marine regression. Amongst the flooding surfaces, the First Flooding Surface can be traced to west-central Alberta.

The gradual regional shifting of facies between the Bearpaw marine tongues and Horseshoe Canyon nonmarine deposits were controlled by relative fluctuations of sea level, which were controlled by global eustasy and regional tectonics. In contrast, frequent facies changes at particular locations may have been controlled by basement discontinuities.

Ten coal seams are developed in the Edmonton area. Seams #1, #2 and #3 are correlated with the Basal Coal Zone in the Drumheller area. Seams #4, #5 and #6 are correlated with the Lower Drumheller Coal Zone in the Drumheller area. Seams #7 and #8 are most likely equivalent to those in the Upper Drumheller Coal Zone in the Drumheller area. Seams #9 and #10 appear to be correlative to the Daly/Weaver Coal Zone.

In the Edmonton area, coal seams are mainly of sub-bituminous rank and highly fractured. Strike of the face cleats is N40-45°E (perpendicular to the Rocky Mountain Thrust Belt) and strike of the butt cleats is N50°-45°W, roughly perpendicular to the face cleats.

Further information on this study may be found in EUB/AGS Geo-Note 2005-08. ❖

Map illustrating the study area in central and southern Alberta.

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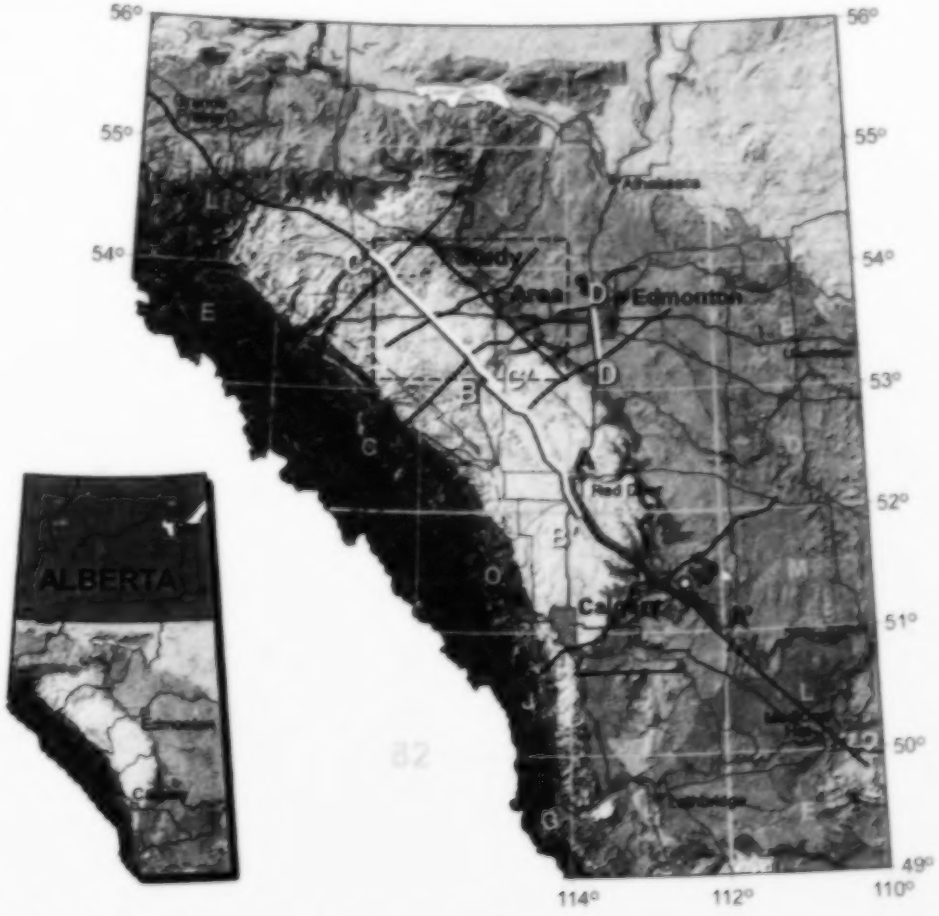

Map illustrating the study area in central and southern Alberta.

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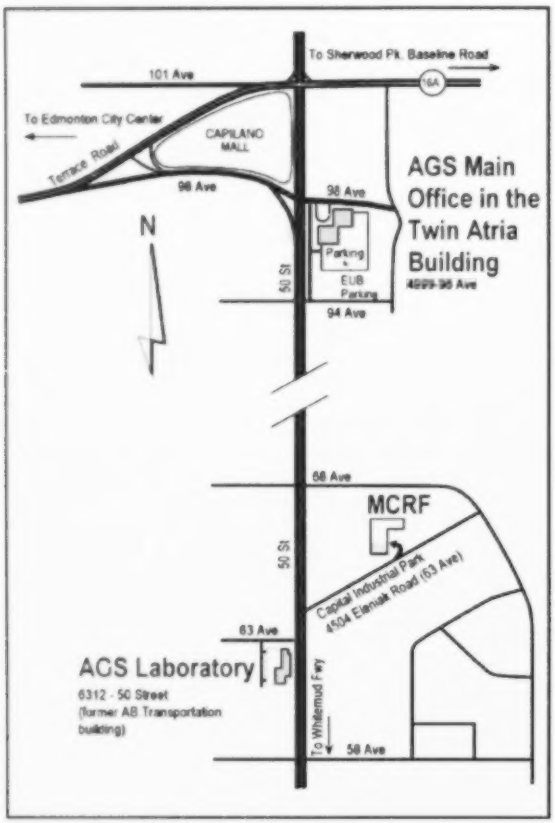

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